acid. But whatever be the case with regard to the origin of the cuticle, I must certainly protest most decidedly against Hartig's representation that the cuticle consists of three layers, and that the membranes penetrating into the interior of the leaf are a continuation of only one of these layers, the innermost, and that they form hollow, vessel-like tubes in the intercellular passages, since I have not observed a single circumstance that would afford a confirmation of any one of these statements.

XXVIII.—*Researches into the Structure, Functions and Œconomy of the* Araneidea. By John Blackwall, F.L.S.*

In essaying to give an epitome of some investigations recently made in this country relative to the organization, physiology and œconomy of the *Araneidea*, I shall endeavour to accomplish the undertaking in as compendious a manner as may be deemed compatible with a perspicuous statement of the various facts to be detailed, distinguishing those already before the public from such as are not by references to the works in which they have appeared.

Without further preface, I proceed to the consideration of those remarkable appendages termed *scopulæ* or brushes, with which the tarsi of numerous species of spiders are provided. This apparatus, consisting of coarse, compound, hair-like papillæ either distributed along the inferior surface of the tarsi or situated immediately below the claws at their extremity, bears a close analogy to the tarsal cushions of insects, enabling its possessor to ascend the perpendicular surfaces of highly polished bodies and even to adhere to smooth objects in an inverted position by the emission of a viscous secretion†. The different plans according to which the papillæ are disposed upon the tarsi are respectively represented by two common British spiders, *Drassus sericeus* and *Salticus scenicus*.

Some of the spiders belonging to the families *Theridiidæ* and *Epëiridæ* have the sides and lower part of the tarsi, at their extremity, supplied with several small, curved, dentated claws, in addition to the three larger ones common to them all. *Epëira quadrata*, *Epëira apoclisa*, and, indeed, most of the larger species of *Epëiræ* indigenous to Great Britain, exhibit this structure to advantage under the microscope; they have, besides, a strong, moveable spine, inserted near the termination of the tarsus of each posterior leg, on the under side, which curves a little upwards at its extremity, and presents a slight irregularity of outline at its superior surface. These spines, which have been denominated *sustentacula*, subserve an important purpose. By the contraction of their flexor muscles they are drawn towards the foot, and are thus brought into direct opposition to the claws, by which means the animals are enabled to hold with a firm grasp such lines as they have occasion to draw from the spinners

* From the Report of the Meeting of the British Association held at York 1844.

† Transactions of the Linnæan Society, vol. xvi. pp. 768, 769. Researches in Zoology, p. 289.

with the feet of the hind-legs, and such also as they design to attach themselves to*.

There are on the superior part of the metatarsus of the posterior legs of all the *Ciniflonidæ* two parallel rows of moveable spines commencing just below its articulation with the tibia and terminating near its lower extremity. In a state of repose, the spines composing both rows are directed down the joint and are somewhat inclined towards each other; those of the upper row have a considerable degree of curvature and taper gradually to a fine point, those of the lower row being stronger, more closely set, and less curved. Employed to transform, by the process of curling, certain lines proceeding from the spinners into the small flocculi characteristic of the snares of the *Ciniflonidæ*, the double series of spines has received the name of *calamistrum*.

When a spider of this family purposes to form a flocculus, it presses its spinners against one of the glossy lines constituting the foundation of its snare, and, emitting from them a small quantity of liquid gum, attaches to it several slender filaments, drawn out by advancing the abdomen a little, and kept distinct by extending the spinning mammulæ laterally. The posterior legs are then raised above the plane of position, and the tarsal claws of one of them are applied to the superior surface of the metatarsus of the other, near its articulation with the tarsus, and the *calamistrum* is brought immediately beneath the spinners, at right angles with the line of the abdomen. By a slight extension of the joints of the posterior legs the *calamistrum* is directed backwards across the diverging extremities of the spinners, which it touches in its transit, and is restored to its former position by a corresponding degree of contraction in the joints. In proportion to the continuation of this process the inflected lines of the flocculus are produced, the spider making room for them as they accumulate by elevating and at the same time advancing the abdomen a little, which it effects by slightly extending the joints of the third pair of legs and contracting those of the first and second pairs. When the requisite quantity of inflected filaments is obtained, the spider again applies its spinners to one of the glossy lines and attaches the flocculus to it. In this manner it proceeds with its labours, occasionally employing both *calamistra*, till the snare is completed. The *modus operandi* appears to be this. The points of the lower row of spines in passing over the extremities of the spinners draw from them lines which run into numerous flexures in consequence of not being kept fully extended, and the purpose subserved by the spines of the upper row is the detachment of these lines from the spines of the lower row by a motion upwards†.

If the metatarsus of one of the posterior legs of *Ciniflo ferox*, a spider of frequent occurrence in the interior of buildings, be examined under the microscope with a moderately high magnifying power, the arrangement of the spines composing the two rows which constitute the *calamistrum* will be apparent.

* Transactions of the Linnæan Society, vol. xvi. p. 476; vol. xviii. p. 224, note *.

† Ibid. pp. 471–475; vol. xviii. pp. 224, 606.

Four, six, or eight mammulæ, somewhat conical or cylindrical in figure, and composed of one or more joints each, constitute the external spinning apparatus of the *Araneidea*: they are usually closely grouped in pairs at the extremity of the abdomen, and are readily distinguished from each other by their relative positions. The pair situated nearest to the anus may be denominated the superior spinners; that furthest removed from the anus, the inferior spinners; and the mammulæ placed between these extremes, the intermediate spinners; distinguishing them, when there are two pairs, by prefixing the terms superior and inferior. Exceedingly fine, moveable papillæ or spinning tubes, for the most part dilated at the base, occur at the extremity of the mammulæ, or are disposed along the inferior surface of their terminal joint, whence issues the viscous secretion of which all the silken lines produced by spiders are formed. The papillæ connected with the mammulæ vary greatly in number in different species of spiders, and also differ considerably in size, not only in individuals of the same species, but often even on the same mammulæ.

Among our native spiders, the larger species of *Epëiræ* have the mammulæ most amply provided with papillæ; it is probable, however, that the total number does not greatly exceed a thousand even in adult females of *Epëira quadrata*, whose weight is about twenty grains, and in many other species it is much smaller. In *Tegenaria civilis* the total number of papillæ does not amount to four hundred; in *Textrix lycosina* and *Clubiona corticalis* it is below three hundred; in *Segestria senoculata* it scarcely exceeds one hundred; and in many of the smaller spiders it is still further reduced.

A difference in the number and size of the papillæ connected with the several pairs of mammulæ in the same species, and with similar pairs in different species, is also very apparent. In spiders of the genera *Epëira*, *Tetragnatha*, *Linyphia*, *Theridion* and *Segestria*, they are generally much more numerous and minute on the inferior spinners than on the superior and intermediate ones; the last are the most sparingly supplied with them, and in the case of *Segestria senoculata* each has only three large papillæ at its extremity. An arrangement nearly the reverse of this takes place in some of the *Drassi*, and is conspicuous in *Drassus ater*, which has the intermediate spinners abundantly furnished with papillæ, those on the inferior spinners being very few in number and chiefly of large dimensions, emitting the viscous secretion copiously. The papillæ connected with the short terminal joint of each inferior spinner of this species vary in number with the age of the animal; the young, on quitting the cocoon, are provided with four only; individuals which have attained nearly a third of their growth have five or six; those about two-thirds grown, six or seven; and adults, which have acquired their full complement, eight; two of them, situated on the inferior surface of the spinner, at a greater distance from its extremity than the rest, are minute and almost contiguous. It is a fact deserving of notice, that the papillæ are not always developed simultaneously on these spinners, six, seven, or eight being sometimes ob-

served on one, when five, six, or seven only are to be seen on the other; and this remark is applicable, not to the inferior spinners alone, but to the intermediate ones also, which, in mature individuals, are further modified by having the extremities of the terminal joints directed downwards at right angles to their bases. The same law of development holds good as regards the papillæ connected with the inferior spinners of *Drassus cupreus* and *Drassus sericeus*, and though their number is not uniformly the same even in adults of either of these or the preceding species, yet the two minute ones belonging to each mammula are present invariably*.

The superior spinners of many spiders are triarticulate; and when the terminal joint is considerably elongated, thickly clothed with hairs, and tapers to a point, the papillæ, in the form of hair-like tubes dilated at the base, are commonly distributed along its inferior surface, as in the case of *Agelena labyrinthica*, *Tegenaria domestica*, and *Textrix lycosina*. This deviation from the prevailing structure has induced Lyonnet, Savigny, Treviranus, Audouin, and other skilful zootomists, who have failed to detect the papillæ, to regard the superior mammulæ, thus modified, as anal palpi, and to deny that they perform the office of spinners; but if these parts be carefully examined with a powerful magnifier in living specimens during the exercise of their function, the fine lines of silk proceeding from the papillæ cannot fail to be discerned, and a correct knowledge of their external organization may thus be obtained. Not being aware, apparently, of the publication of this discovery in the 'Report of the Third Meeting of the British Association for the Advancement of Science, held at Cambridge in 1833,' p. 445, Baron Walckenaer, in the Supplement to the second volume of his 'Histoire Naturelle des Insectes Aptères,' p. 407, has ascribed it to M. Dugès, whose observations on the subject in the 'Annales des Sciences Naturelles,' seconde série, t. vi., Zoologie, p. 166, were not published till 1836.

One of the most striking peculiarities in the structure of the *Cinifloniдæ*, which serves to distinguish them from all other animals of the order *Araneidea* at present known, is the possession of a fourth pair of spinners. These spinners are shorter and further removed from the anus than the rest, being situated at the base of the inferior intermediate pair, by which they are almost concealed when in a state of repose. Their figure is somewhat conical, but compressed and truncated, so that the base and apex are elliptical with long transverse axes. Consisting of a single joint only, each is connected with the other throughout its entire length, the extremity alone being densely covered with exceedingly minute papillæ, which emit the viscous matter that is formed by the *calamistra* into a delicate tortuous band constituting a portion of every flocculus in the snares of these spiders, and chiefly imparting to them their most important property, that of adhesion†.

Arachnologists have not bestowed that degree of attention on the

* Transactions of the Linnæan Society, vol. xviii. p. 219–224.

† Ibid. pp. 223, 224, 606.

palpi of spiders to which their diversified structure and important functions undoubtedly entitle them.

Much difference is observable in the relative proportions of the several joints of the palpi of female spiders, not only in species constituting the same family, but even in those belonging to the same genus; while, on the other hand, it frequently happens that females belonging to different genera bear a striking resemblance to each other in this particular. It is among male spiders, however, that these peculiarities are the most marked, and to them may be added structural differences and resemblances both of the palpi and sexual organs still more conspicuous.

A great similarity in the form of the organs of reproduction, in the simplicity of their structure, and in the manner of their connexion with the digital joint of the palpi, which has no cavity opening externally, may be seen in certain males of the family *Dysderidæ*; in *Dysdera erythrina*, *Dysdera Hombergii*, *Segestria perfida*, *Segestria senoculata*, and *Oonops pulcher*, for example; and this similitude is extended to the males of various species belonging to the family *Mygalidæ*.

Between the males of *Pachygnatha Clerckii* and *Tetragnatha extensa* there is a near approximation in the structure of the palpi and sexual organs, yet these spiders are not included in the same family, the former belonging to the *Theridiidæ*, and the latter to the *Epëiridæ*.

If the spiders constituting the genus *Clubiona* be compared with those of the genus *Drassus*, and those of the genus *Linyphia* with the species comprised in the genus *Neriëne*; or, extending the investigation still further, if the genera *Walckenaëra*, *Theridion*, *Epëira*, *Eresus*, *Salticus*, *Thomisus*, and *Philodromus* be compared together, numerous instances of correspondence in the relative proportions of the joints of the palpi will be perceived immediately; at the same time, striking contrasts will present themselves to the eye of the observer, not as regards proportion alone, but organization also, even among nearly allied species.

As the full development of the palpi and the organs of generation connected with them indicates a state of maturity in male spiders, the skilful arachnologist is enabled, by attending to this circumstance, not only to distinguish adult males from females, but likewise from immature individuals of both sexes. This knowledge is useful in preventing him from falling into the too common error of mistaking young spiders for old ones, and of describing them, and the sexes of spiders of the same kind, as distinct species. When any doubts exist as to the specific identity of adult spiders of different sexes, they frequently may be set at rest by placing the spiders together in captivity and noticing whether they pair or not.

The great diversity of structure observable in the palpi and sexual organs of male spiders supplies excellent specific characters, and, indeed, frequently presents the only available means of distinguishing species of similar colours and dimensions from each other; but when it is borne in mind that this diversity of structure extends to spiders

connected by the closest relations of affinity, it is, perhaps, in vain to expect that it will ever be applied with much success to the establishment of genera.

From remarks on the structure of the palpi to the consideration of the functions they perform the transition is easy and natural.

Many spiders employ their palpi in assisting to collect the slack line which results from their operations when engaged in ascending the silken filaments by which they have lowered themselves from stations previously occupied, or in drawing in such as have been emitted from the spinners for the purpose of facilitating a change of situation in some other direction. The silk collected on these occasions is formed into a small heap, which is either attached to some fixed object, or is transferred to the maxillæ, and, after having been mixed with saliva and reduced in volume by repeated acts of compression, is ultimately allowed to fall to the ground.

In conjunction with the mandibles, the palpi are employed by females of the species *Dolomedes mirabilis* and *Dolomedes fimbriatus* to retain their cocoons under the sternum, in which situation those spiders usually carry them wherever they move. The *Lycosæ* also avail themselves of the same parts in regaining possession of their cocoons when detached from the spinners.

Certain spiders belonging to the genus *Mygale* have the inferior part of the tarsi furnished with a dense brush of hair-like papillæ for the emission of a viscous secretion, which enables them to ascend bodies having smooth perpendicular surfaces. Now, as the females of these species usually have the under side of the digital joint of their palpi, which are remarkably long and powerful, supplied in like manner with papillæ, analogy would lead to the conclusion that, in harmony with their organization and distribution, they also constitute a climbing apparatus.

Various species of *Salticidæ*, to which distinctness and accuracy of vision are of the utmost consequence, as they do not construct snares, but capture their prey by springing suddenly upon it from a distance, have the terminal joint of the palpi abundantly supplied with hairs, and constantly make use of those organs as brushes to remove dust, or any other extraneous matter, from the corneous coat of the anterior eyes.

The palpi appear to afford direct assistance likewise to spiders in general in securing their prey, in changing its position while they are feeding upon it, and in restraining the action of the wings of all their victims which happen to be provided with them*.

With regard to the function exercised by the remarkable organs connected with the digital joint of the palpi of male spiders there exists some difference of opinion. Taking anatomy as his guide, Treviranus arrived at the conclusion that the parts in question are used for the purpose of excitation merely, preparatory to the actual union of the sexes by means of appropriate organs situated near the anterior part of the inferior region of the abdomen. This view of

* Report of the Twelfth Meeting of the British Association for the Advancement of Science, held at Manchester in 1842; Transactions of the Sections, pp. 67, 68.

the subject, which is very generally adopted, is opposed to that derived from physiological facts by Dr. Lister and the earlier systematic writers on arachnology, who regarded the palpal organs as strictly sexual.

Rejecting the opinion of Treviranus, Baron Walckenaer has given his support to that entertained by Lister and the physiologists, having endeavoured to establish its accuracy by pursuing the imperfect method of investigation employed by the latter, which chiefly consists in examining the condition of the palpal organs when applied by male spiders to the vulva of females and carefully noticing the changes they undergo; but as it is possible that such females, should they prove to be prolific, may have been impregnated at a former period, and as other organs than those connected with the digital joint of the palpi may have been instrumental in producing the result, observations of this description appear to be quite inadequate to effect the object proposed.

An attempt to relieve the inquiry from objections so weighty is recorded in the 'Report of the Third Meeting of the British Association for the Advancement of Science, held at Cambridge in 1833,' pp. 444–5, and the result arrived at has a direct tendency to confirm the truth of the opinion promulgated by Dr. Lister. Since that time, researches in connexion with this subject have been greatly extended and varied, and it is satisfactory to add, that they supply a body of evidence which appears to be conclusive as to the agency of the palpal organs.

The following is a concise summary of the more important particulars elicited by this investigation.

It is an admitted fact, that female *Aphides*, when impregnated, are capable of producing females which, without sexual intercourse, are prolific through several successive generations. In order to determine whether this is the case with spiders or not, young females of the species *Tegenaria domestica*, *Tegenaria civilis*, *Agelena labyrinthica*, *Ciniflo atrox*, *Drassus sericeus*, *Theridion quadripunctatum*, *Segestria senoculata*, &c., were placed in phials of transparent glass and fed with insects. Most of these individuals remained in captivity from one to three years after they had completed their moulting and attained maturity; yet three only, an *Agelena labyrinthica*, a *Tegenaria domestica*, and a *Tegenaria civilis*, produced eggs, and they proved to be sterile, though several of the others, to which adult males were subsequently introduced, laid prolific eggs after coition. It is worthy of remark, that the spiders which produced unfruitful eggs deposited them in cocoons and bestowed the same care upon them as if they had been fertile.

This preliminary point being settled, attention was directed in the next place to spiders in a state of liberty, when it was perceived that the males of various species do not bring any part of the abdomen near the vulva of the females in the act of copulation, and that this is the case with the *Lycosæ* in particular; for example, the male of *Lycosa lugubris*, after having made the customary advances, springs suddenly upon the back of the female with his head directed towards her spinners and the anterior part of the inferior surface of

the abdomen resting upon her cephalothorax; then placing the first pair of legs immediately behind her posterior pair, the second pair between her second and third pairs, the third pair between her first and second pairs, and the posterior pair before her first pair, he thus embraces her, and applies the palpal organs to the vulva by inclining to one side or the other as the occasion may require. In this situation the male remains till the act of union is consummated and then quits it with precipitancy, so that his abdomen is not even brought into contact with that part, much less with the vulva, of the female.

Precisely the same manner of proceeding is pursued by *Lycosa agretyca*, *Lycosa saccata*, *Lycosa pallida*, and *Lycosa obscura*; and females of the last species have been seen to receive the embraces of several males in immediate succession, and to copulate even at the time they had cocoons containing newly-laid eggs attached to their spinners, which circumstances serve to support the opinion that some spiders pair oftener than once in the course of their lives.

When in captivity, the sexes of *Lycosa lugubris* sometimes continue paired more than four hours, during which period the male applies the palpal organs several hundred times to the vulva of the female.

Notwithstanding the important bearing of these observations upon the physiological problem under consideration, something was still wanting to complete its solution, and recourse was had to direct experiment to supply the desideratum.

On the 4th of May 1842, an adult male *Tegenaria civilis* was procured, and, being held by the legs in an inverted position, the inferior surface of the abdomen was moistened by applying to it a camel's hair pencil which had been dipped in water. The entire interval between the plates of the spiracles, supposed by Treviranus to be the seat of the sexual organs in male spiders, and even a considerable space below that interval, was then covered with strong, well-gummed writing-paper cut into a suitable form and closely applied, and when the paper became thoroughly dry and firmly attached, the spider was placed in a phial with a female of the same species, which had been in solitary confinement from the 2nd of June 1841, and had cast its skin twice during its captivity. With this female the male paired on the same day he was introduced to her, applying the palpal organs to the vulva in the usual manner, and immediately after the union was completed he was removed from her. On the 23rd of May she deposited a set of eggs in a cocoon spun for their reception, and on the 11th of June she constructed another cocoon in which she laid a second set of eggs. All these eggs proved to be prolific, the extrication of young spiders from the first set commencing on the 26th of June, and from the second set on the 13th of July, in the same year. Without renewing her intercourse with the male, this female deposited a set of eggs in a cocoon on the 2nd of April, the 9th of May, the 4th of June, the 22nd of June, and the 9th of July 1843, and on the 22nd of April, the 30th of May, the 29th of June, and the 1st of August 1844, respectively, nine sets in number, all of which produced young.

Another male *Tegenaria civilis*, after undergoing the same treatment exactly as that in the preceding experiment, was introduced, on the 6th of May 1842, to a female of its own species, which had been in solitary confinement from the 25th of January 1840, and had cast its skin three times during its captivity. This female received the embraces of the male as soon as he was admitted into the phial to her, and laid a set of eggs on the 27th of the same month, all of which were productive, the young beginning to be disengaged from them on the 27th of the ensuing month.

In stating a further repetition of this experiment with spiders of the same species, it is only necessary to premise that the female had cast her skin three times in captivity, and that the male had but the right palpus, the other having been removed by amputation. They were placed together on the 16th of May 1842, paired the same day, and were separated as soon as their union was accomplished. On the 19th of June the female deposited a set of eggs in a cocoon, which began to be hatched on the 24th of the following July, and all produced young. Without further sexual intercourse, in 1843 she enveloped a set of eggs in a cocoon on the 7th of April, the 5th of May, the 1st of June, the 18th of June, and the 3rd of July, respectively, from all which young were disengaged.

Promptness in accommodating itself to the restraint of confinement, together with the certainty of being able to procure specimens whenever they might be required, led to the selection of *Tegenaria civilis* as a suitable subject for the foregoing experiments, from which, conjointly with the preceding observations, the following inferences may be deduced:—

1st. That female spiders are incapable of producing prolific eggs without sexual intercourse.

2nd. That females which have not been impregnated occasionally produce sterile eggs.

3rd. That the female of *Tegenaria civilis*, when impregnated, is capable of producing several sets of prolific eggs in succession without renewing its intercourse with the male*, two years or more occasionally elapsing before all are deposited, and a period of ten months nearly intervening sometimes between the deposition of two consecutive sets.

4th. That spiders of various species copulate without the abdomen of the male being brought into contact with that of the female.

5th. That male spiders, in which the part, stated by Treviranus to be the seat of the sexual organs, is entirely covered with strong, well-gummed writing paper closely applied, nevertheless possess the power of exercising the function of generation unimpaired.

6th. Lastly, that males so circumstanced invariably consummate the act by applying the palpal organs to the vulva of females, plainly demonstrating thereby the interesting truth, that those organs, however anomalous their situation may be, are the only efficient

* *Tegenaria domestica* (*Aranea domestica*, Linn.), *Agelena labyrinthica*, and *Epëira cucurbitina* are endowed with similar powers of production. *Vide* the Report of the Third Meeting of the British Association, p. 445.

instruments employed by male spiders in the propagation of their species.

Before they arrive at maturity spiders change their skin several times: the manner in which these moults are effected may be illustrated by describing the proceedings of an individual of the species *Epëira calophylla*. Preparatory to casting its integument, this spider spins some strong lines in the vicinity of its snare, from which it suspends itself by the feet and a filament proceeding from the spinners. After remaining for a short time in this situation, the coriaceous covering of the cephalothorax gives way laterally, disuniting at the insertion of the legs and mandibles; the line of separation pursues the same direction till it extends to the abdomen, which is next disengaged, the extrication of the legs being the last and greatest difficulty the spider has to overcome. As the suspensory filament connected with the spinners of the exuviæ is considerably shorter than the legs and does not undergo any sensible alteration in length, the abdomen, during the process of moulting, becomes gradually deflected from its original horizontal direction till it assumes a vertical position nearly at right angles with the cephalothorax. By this change of posture, attended with numerous contortions of the body, and alternate contractions and extensions of the limbs, the spider is ultimately enabled to accomplish its purpose. When it has completely disengaged itself from the slough, it remains, for a short period, in a state of great exhaustion, suspended solely by a thread from the spinners, connected with the interior of the abdominal portion of the cast skin, which is much corrugated. After reposing a little, the spider further attaches itself to the suspensory lines by the claws of the feet, and when its strength is sufficiently restored, and its limbs have acquired the requisite degree of firmness, it ascends its filaments and seeks its retreat*.

Recent observations establish the fact, that the number of times spiders change their integument before they become adult is not uniformly the same as regards every species. A young female *Epëira calophylla*, disengaged from the egg on the 30th of March 1843, moulted on the 8th of the ensuing month in the cocoon, which it quitted on the 1st of May; moulting again, in the same year, on the 4th of June, the 22nd of June, the 12th of July, and the 4th of August, respectively, when it arrived at maturity, having cast its skin five times.

An egg of *Epëira diadema*, hatched on the 14th of April 1843, produced a female spider, which moulted in the cocoon on the 24th of the same month; on the 3rd of May it quitted the cocoon, and moulted again on the 21st of June, the 10th of July, the 3rd of August, and the 23rd of August, in the same year. On the 28th of February 1844 it died in a state of immaturity after having completed its fifth moult.

On the 27th of June 1842 an egg of *Tegenaria civilis* produced a female spider, which underwent its first moult in the cocoon on the 10th of the ensuing July; quitting the cocoon on the 21st of the

* Transactions of the Linnæan Society, vol xvi. p. 482–484.

same month, it moulted again on the 17th of August, the 4th of September, and the 26th of September, in the same year; and on the 26th of January, the 9th of April, the 24th of May, the 21st of June, and the 5th of August in 1843, when it arrived at maturity, having changed its integument nine times.

A male *Tegenaria civilis*, extricated from the egg on the 27th of June 1842, also moulted nine times, casting its skin in the cocoon on the 10th of the following July; on the 21st of the same month it abandoned the cocoon, moulting again on the 13th of August, the 10th of September, and the 13th of October, in the same year; and on the 1st of February, the 25th of April, the 17th of June, the 13th of July, and the 17th of October in 1843, when its development was complete.

Modifications of food and temperature exercise a decided influence upon the moulting of spiders. A young female *Tegenaria civilis* disengaged from the egg on the 24th of July 1842, on the 2nd of the following August moulted in the cocoon, which it quitted on the 12th of the same month, casting its skin again on the 29th of August, and the 10th of October, in the same year; being scantily supplied with nutriment, it increased very little in size, and died on the 4th of July 1843, having changed its integument three times only. Another female of the same species, which was extricated from the egg on the same day as the foregoing individual, and was well-fed, on the 13th of July 1843 had moulted seven times. It is apparent also from the particulars already stated, that the intervals between consecutive moults are much shorter when the temperature of the atmosphere is high than when it is low.

Immature spiders infested by the larva of *Polysphincta carbonaria*, an insect belonging to the family *Ichneumonidæ*, which feeds upon their fluids, never change their integument*.

Like certain animals of the class *Crustacea*, spiders possess the property of reproducing such limbs as have been detached or mutilated, and this curious physiological phænomenon is intimately connected with the renovation of the integument, as it is observed to take place at the time of moulting only. Experiments illustrative of this interesting subject have been multiplied to a very great extent; in introducing some of them to notice, such have been selected, as from the novel and important conclusions deducible from them are best deserving of attention.

1. A young male *Textrix lycosina* had half of the terminal joint of each superior spinner amputated, and the posterior leg on the right side detached at the coxa, on the 3rd of August 1838. It moulted on the 10th of September, reproducing the detached parts, which were small but perfect in structure. On the 23rd of February 1839 it moulted again and became adult; at the same time a sensible increase took place in the bulk of the reproduced parts, which, nevertheless, were still defective in point of size.

2. On the 23rd of August 1838 a young female *Tegenaria civilis*

* Annals and Magazine of Natural History, vol. xi. p. 1–4.

had the anterior leg on the right side and the third leg on the left side detached at the coxa, the terminal joint of the superior and inferior spinners on the right side being amputated at the same time. This spider moulted on the 27th of September, when the detached parts, of a smaller size than the corresponding parts on the opposite side, but perfect in structure, were reproduced. On the 6th of November it changed its integument a second time, and on the 16th of June 1839 a third time, when it arrived at maturity. The reproduced parts advanced perceptibly in growth at each successive moult, but did not ultimately acquire their full dimensions.

3. A young male *Tegenaria civilis* had the digital joint of the left palpus, which was very tumid, detached on the 6th of October 1838. It moulted on the 17th of June 1839 and reproduced the left palpus, which, though small, had the radial joint provided with the apophysis characteristic of a state of maturity in this species. The sexual organs, however, were altogether wanting, and the digital joint was slightly modified in size and form by this circumstance. It is scarcely necessary to remark that the sexual organs connected with the right palpus were fully developed.

4. The digital joint of the left palpus of a young female *Segestria senoculata* was amputated on the 18th of May 1839. This spider cast its integument on the 8th of July, the left palpus, of a small size, being reproduced. It moulted again on the 28th of June 1840, when the reproduced palpus had its dimensions enlarged and the spider arrived at maturity. On the 12th of December 1842 it died, having existed nearly three years and a half in captivity.

5. On the 8th of June 1839 a young female *Agelena labyrinthica* had the terminal joint of each superior spinner amputated. Bringing the extremities of the tarsi of the posterior legs to the mouth, it moistened them with saliva, and repeatedly applied them to the mutilated parts. On the 21st of the same month it moulted, and the superior spinners, of a small size, were reproduced. It moulted again on the 12th of the ensuing July, when the reproduced spinners were increased in size, and it arrived at maturity.

6. A young male *Textrix lycosina* had the terminal joint of each superior spinner amputated, and the third leg on the right side detached at the coxa, on the 25th of July 1839. This spider cast its integument on the 6th of the ensuing August, when the stumps only of the mutilated parts were produced. On the 2nd of December, in the same year, it moulted again; the superior spinners and third leg on the right side, of a small size, were then reproduced, and it arrived at maturity.

7. The left palpus of a young male *Tegenaria civilis*, the digital joint of which was very tumid, was amputated at the axillary joint on the 15th of January 1840. On the 22nd of June, in the same year, it moulted, reproducing the left palpus, which was of small dimensions. The radial joint was provided with an apophysis, indicating the mature state of the spider, but the digital joint was somewhat modified in size and form, and the sexual organs were not reproduced.

8. A young male *Tegenaria civilis* had the right palpus amputated at the axillary joint on the 15th of January 1840. It moulted on the 2nd of the following June, when the detached part, of a small size, was reproduced and the digital joint became very tumid. On the 12th of August, in the same year, it moulted again; the right palpus was augmented in size, the radial joint was furnished with an apophysis, and the sexual organs, complete in their organization, were developed; these several parts, however, were still decidedly smaller than the corresponding parts of the left palpus.

9. On the 25th of January 1840 the left palpus of a young female *Tegenaria civilis* was amputated at the axillary joint. This spider moulted on the 1st of the ensuing May, at which time the detached part, of a small size, was reproduced. On the 20th of June and the 6th of August, in the same year, it moulted again and arrived at maturity, the left palpus receiving an increase in size at each successive moult.

10. A young male *Ciniflo ferox* had the cubital, radial and digital joints of the left palpus amputated on the 26th of May 1840. It moulted on the 18th of the following June and reproduced the left palpus, which was small, with the digital joint very tumid. On the 8th of August, in the same year, it moulted again, when the left palpus was enlarged, the apophyses of the radial joint were produced, and the sexual organs were developed. Though the several parts of the left palpus were smaller than the corresponding parts of the right palpus, yet they were perfect in their organization.

11. The left palpus of a young male *Ciniflo atrox* was amputated at the axillary joint on the 28th of May 1840. This spider changed its integument on the 27th of the following June, and reproduced the left palpus, which had the digital joint very tumid. On the 11th of August, in the same year, it moulted again, when the apophyses of the radial joint and the sexual organs, perfect in structure, were developed, but all the parts of the left palpus were smaller than the corresponding parts of the right palpus.

12. A young male *Linyphia cauta* had the right palpus at the axillary joint, the cubital, radial and digital joints of the left palpus, and the tibiæ and tarsi of the first, second and third legs on the left side amputated on the 30th of May 1840. On the 25th of the ensuing June it moulted, when the stumps only of the palpi were produced, but the mutilated legs, of small dimensions, were reproduced. It moulted again on the 21st of July, in the same year, and though the palpi still were not reproduced, yet the newly-formed legs were augmented in size and the spider arrived at maturity.

13. The digital joint of the left palpus of a young male *Linyphia cauta*, which was very tumid, was amputated on the 20th of July 1840. The spider moulted on the 19th of the following August, reproduced the left palpus, of a small size, with the digital joint considerably modified, and at the same time arrived at maturity; but the sexual organs were not reproduced.

14. A young male *Tegenaria civilis* had the right palpus amputated at the axillary joint on the 9th of June 1841. On the 13th of

the following July it cast its integument and reproduced the right palpus, which, though small, had the digital joint very tumid. It moulted again on the 20th of August, in the same year, when the dimensions of the right palpus were augmented, the radial joint was provided with an apophysis, and the sexual organs were developed. The organization of the right palpus was perfect in all its parts, but they were smaller than the corresponding parts of the left palpus.

15. On the 25th of June 1841 a young male *Drassus sericeus* had the cubital, radial and digital joints of the left palpus amputated, the digital joint being very tumid. It moulted on the 16th of the ensuing August and reproduced the left palpus, of a small size; the radial joint was provided with an apophysis, indicating the mature state of the spider, but the sexual organs were not reproduced.

16. A young male *Ciniflo ferox* had the right palpus amputated at the axillary joint on the 2nd of July 1841. On the 19th it moulted, but the stump only of the mutilated part was produced. On the 28th of the same month the left palpus was amputated at the axillary joint. The spider moulted again on the 28th of the ensuing August, when both the palpi, of a small size, were produced.

17. The anterior leg on the left side of a young female *Tegenaria civilis* was amputated at the coxa on the 1st of September 1842. This spider was dissected on the 14th of the following October, when on the point of moulting, as was evident from the deepened hue of the integument and from the perfect structure of the tarsal and palpal claws, visible through it. The anterior leg on the left side, which was reproduced, was complete in its organization, $\frac{7}{24}$ths of an inch in length, and was curiously folded in the integument of the old coxa, which measured only $\frac{1}{24}$th of an inch in length.

18. A young male *Tegenaria civilis* had the posterior leg on the left side amputated near the middle of the tibia on the 24th of April 1843, when it moistened the tarsus of the third leg on the same side with saliva and repeatedly applied it to the mutilated limb. Being about to moult, this spider was dissected on the 5th of the ensuing June; the posterior leg on the left side, which was reproduced, was found to have its tarsal and metatarsal joints folded in the undetached half of the integument of the old tibia.

A recapitulation of the more remarkable results obtained from the experiments, elucidated in several instances by additional facts and observations, will not, it is presumed, be deemed superfluous.

Physiologists, in conducting researches relative to the reproduction of the limbs of spiders, seem to have limited their investigations to the legs of those animals; whereas, in the experiments detailed above, the palpi and spinners, as well as the legs, were operated upon; and all these parts are found to be renewed, and afterwards to have their dimensions enlarged at the period of moulting only; it appears also that if a part of a limb be amputated, as the tarsus of a leg or the digital joint of a palpus, the whole is reproduced, all the joints of the new limb, though small, being proportionate to those of the corresponding limb on the opposite side, with the exception of the digital joint of the palpi of male spiders when the sexual organs

are not reproduced, which is usually somewhat modified in size and form by that circumstance.

At the penultimate moult of male spiders the digital joints of the palpi become very tumid, in much the greater number of species, by a sudden and rapid advance towards development in the sexual organs, and should those parts be detached during the interval which elapses between that and the succeeding moult, though the palpi, indicating by their organization that the animal has arrived at maturity, may be reproduced, yet the sexual organs are always absent. (See experiments 3, 7, 13, 15.) Adult males of the species *Lycosa obscura*, *Dysdera Hombergii*, and *Philodromus dispar* have been found in a state of liberty with the palpi unequal in size and the smaller one entirely destitute of the sexual organs.

When the palpi of male spiders, which had been amputated before the penultimate moult, are reproduced, the sexual organs, perfect in structure, are reproduced also (see experiments 8, 10, 11, 14); unexceptionable evidence in support of this singular fact is to be found in their reduced dimensions and integrity of form, but it will scarcely be denied that the original germs of those organs must have been removed with the detached palpi. That the function of the sexual organs is not in the least affected by their reproduction there exists the most satisfactory proof. In the last of those experiments, having for their object the determination of the seat of the sexual organs in male spiders, recorded in this report, the male *Tegenaria civilis*, stated to have possessed the right palpus only when introduced to the female, is identical with that which was the subject of experiment 8 in the foregoing series; consequently, its sexual organs had been reproduced, yet the fertility of its mate bore ample testimony to the unimpaired efficiency of their generative agency.

If experiments 6 and 16 be referred to, it will be seen that the stumps only of mutilated parts are occasionally produced at the following moult, and that the entire parts, of a small size, are sometimes restored at a subsequent moult.

Experiment 12 presents an extraordinary case of the stumps of the palpi being produced at two consecutive moults after they had suffered mutilation, though several legs of the same spider, mutilated at the same time, were renewed at the next moult after the infliction of the injury.

The fact, that reproduced legs, immediately antecedent to the process of moulting, are folded in the integument of the undetached portion of the mutilated limbs, is clearly established by experiments 17 and 18.

With some spiders the duration of life does not exceed the brief space of twelve months, whereas it may be safely inferred from experiment 4 that *Segestria senoculata* does not even complete its several changes of integument and arrive at maturity in less than two years. The individual there stated to have had the digital joint of the left palpus detached on the 18th of May 1839 was then about two-thirds grown, and must have been disengaged from the egg in the summer of the preceding year, as this species breeds in the

months of May and June in North Wales. On the 28th of June 1840, the third summer of its existence, it underwent its last moult and became adult. Subsequent experiments made with both sexes of this spider tend to corroborate the accuracy of the above conclusion.

Variations in the colour and size of spiders of the same kind, resulting from differences in age, sex, food, climate, and other conditions of a less obvious character, as they conduce largely to the introduction of fictitious species, have long engaged the attention of arachnologists, while those arising from extraordinary organic modifications, in consequence, perhaps, of their less frequent occurrence, have been almost entirely overlooked. The importance which cases of the latter description possess in relation to physiology and systematic arrangement will be best illustrated by a few examples.

1. A supernumerary eye, situated between the two small ones constituting the anterior intermediate pair, has been observed in an adult female *Theridion filipes*. The total number of eyes possessed by this individual was nine and their arrangement symmetrical.

2. An immature female *Thomisus cristatus* had the two lateral pairs of eyes only; the four small intermediate ones were altogether wanting, not the slightest rudiment of them being perceptible even with the aid of a powerful magnifier.

3. A short but perfectly formed supernumerary tarsus, connected with the base of the tarsal joint of the right posterior leg on its outer side, has been noticed in an adult female *Lycosa campestris*.

4. Deficiency of the right intermediate eye of the anterior row has been remarked in an adult male *Lycosa cambrica*.

5. The left intermediate eye of the posterior row was perceived to be wanting in an adult female *Epëira inclinata*, and the right intermediate eye of the same row was not half the usual size.

6. An adult female *Ciniflo atrox* was found to be without the left intermediate eye of the posterior row.

7. The right intermediate eye of the posterior row in an adult female *Epëira inclinata* had not one-eighth of the natural size, being merely rudimentary.

The particulars stated in the foregoing cases, which serve to establish the fact, that spiders, in common with many other animals, occasionally exhibit instances of anomalous structure, derive no small degree of interest from their novelty; but when it is borne in mind that all the examples except one have reference to those important organs the eyes, important, not only as regards the function they perform, but also on account of the extensive use made of them in the classification of the Araneidea, that interest becomes greatly augmented.

As spiders with four eyes have not yet been found, it is a matter of some consequence to caution observers against mistaking a mere defect in structure, like that recorded in case 2, for such a discovery. Whether there are species provided with an odd number of eyes or not is at present conjectural; should such exist, symmetry in the arrangement of their visual organs certainly may be expected to ob-

tain; consequently, cases 4, 5 and 6, which present instances of an odd number of eyes disposed irregularly, would be regarded at all times with suspicion; as no such objection, however, can be urged against case 1, a solution of the difficulty it presents must be sought for in a more accurate acquaintance with the species.

Interesting chiefly in a physiological point of view, cases 3 and 7 show that a liability to irregularity in structure is not limited to the eyes, and that those organs are subject to preternatural variations in size as well as number.

The obscurity in which the cause of these remarkable organic modifications is involved, careful investigation, conducted upon sound philosophical principles, can alone dispel*.

Argyroneta aquatica, *Dolomedes fimbriatus*, and *Lycosa piratica* are known to descend spontaneously beneath the surface of water, the time during which they can respire when immersed depending upon the quantity of air confined by the circumambient liquid among the hairs with which they are clothed. There are, however, some spiders of small size, *Erigone atra* and *Savignia frontata*, for example, which, though they do not enter water voluntarily, can support life in it for many days, and that without the external supply of air so essential to the existence of *Argyroneta aquatica* under similar circumstances. It is probable that this property may contribute to their preservation through the winter, when their hybernacula are liable to be inundated†.

Spiders, though extremely voracious, are capable of enduring long abstinence from food. A young female *Theridion quadripunctatum*, captured in August 1829, was placed in a phial and fed with flies till the 15th of October, in the same year, during which period it accomplished its final moult and attained maturity. It was then removed to a smaller phial, which was closely corked and locked up in a bookcase, its supply of food being at the same time discontinued. In this situation it remained till the 30th of April 1831, on which day it died, without receiving the slightest nourishment of any description. Throughout its captivity it never failed to produce a new snare when an old one was removed, which was frequently the case; and it is a fact particularly deserving of attention, that the alvine evacuations were continued, in minute quantities and at very distant intervals, to the termination of its existence‡.

When about to deposit their eggs, spiders usually spin for their reception silken cocoons displaying much diversity of form, size, colour, and consistency. Those of the *Lycosæ* have a lenticular, or spherical figure and compact structure, with the exception of a narrow zone of a delicate texture by which they are encircled. In constructing their cocoons, these spiders slightly connect the margins of the two compact portions, beneath which the thin fabric of the zone is folded. This simple contrivance affords an admirable pro-

* Annals and Magazine of Natural History, vol. xi. p. 165–168.

† Report of the Third Meeting of the British Association for the Advancement of Science held at Cambridge in 1833, p. 446.

‡ Researches in Zoology, pp. 302, 303.

vision for the development of the young in the fœtal state by an enlarged capacity in the cocoons consequent on the margins of the compact parts becoming detached by the expansive force within, the eventual liberation of the young being effected by the rupture of the zone.

Theridion callens fabricates a very remarkable balloon-shaped cocoon about one-eighth of an inch in diameter. It is composed of soft silk of a loose texture and pale brown colour, inclosed in an irregular network of coarse, dark red-brown silk; several of the lines composing this network unite near the lower and smaller extremity of the cocoon, leaving intervals there through which the young pass when they quit it, and, being cemented together throughout the remainder of their extent, form a slender stem, varying from one-tenth to half of an inch in length, by which the cocoon is attached to the surface of stones and fragments of rock, resembling in its figure and erect position some of the minute plants belonging to the class Cryptogamia. The eggs are large, considering the small size of the spider, five or six in number, spherical, not agglutinated together, and of a brown colour*.

An elegant vase-shaped cocoon, composed of white silk of a fine compact texture, and attached by a short foot-stalk to rushes, the stems of grass, heath, and gorse, is constructed by *Agelena brunnea*; it measures about one-fourth of an inch in diameter, and contains from forty to fifty yellowish-white, spherical eggs enveloped in white silk connected with the interior of the cocoon contiguous to the foot-stalk. Greatly to the disadvantage of its appearance, the entire cocoon is smeared with moist soil, which drying serves to protect it from the weather, and as an additional security, the extremity is closed and directed downwards.

Theridion riparium fabricates a slender, conical tube of silk of a very slight texture, measuring from one and a half to two and a half inches in length, and about half an inch in diameter at its lower extremity. It is closed above, open below, thickly covered externally with bits of indurated earth, small stones, and withered leaves and flowers, which are incorporated with it, and is suspended perpendicularly, by lines attached to its sides and apex, in the irregular snare constructed by this species. In the upper part of this singular domicile the female spins several globular cocoons of yellowish-white silk of a slight texture, whose mean diameter is about one-eighth of an inch, in each of which she deposits from twenty to sixty small spherical eggs of a pale yellowish-white colour, not agglutinated together. The young remain with the mother for a long period after quitting the cocoons, and are provided by her with food, which consists chiefly of ants†.

Oonops pulcher constructs several contiguous, subglobose cocoons of white silk of a fine but compact texture in the crevices of rocks and walls, and among lichens growing on the trunks of trees; each

* Transactions of the Linnæan Society, vol. xviii. p. 629.

† Researches in Zoology, p. 356.

measures about one-sixteenth of an inch in diameter and usually comprises two spherical, pink eggs, not agglutinated together. It may be remarked, by way of contrast, that *Epëira quadrata* frequently deposits between nine hundred and a thousand spherical eggs of a yellow colour, in a globular cocoon of coarse yellow silk of a loose texture, measuring seven-tenths of an inch in diameter, which is attached to the stems of heath, gorse, and other vegetable productions in the vicinity of its haunts.

Among the silken snares fabricated by spiders for the purpose of capturing their prey, the most elegant are those constructed with the appearance of geometrical precision in the form of circular nets. They are composed of an elastic spiral line thickly studded with minute globules of liquid gum, whose circumvolutions, falling within the same plane, are crossed by radii converging towards a common centre, which is immediately surrounded by several circumvolutions of a short spiral line devoid of viscid globules, forming a station from which the toils may be superintended by their owner without the inconvenience of being entangled in them. As the radii are unadhesive and possess only a moderate share of elasticity, they must consist of a different material from that of the viscid spiral line, which is elastic in an extraordinary degree. Now the viscidity of this line may be shown to depend entirely upon the globules with which it is studded, for if they be removed by careful applications of the finger, a fine glossy filament remains, which is highly elastic, but perfectly unadhesive. As the globules, therefore, and the line on which they are disposed, differ so essentially from each other, and from the radii, it is reasonable to infer that the physical constitution of these several portions of the net must be dissimilar.

An estimate of the number of viscid globules distributed on the elastic spiral line in a net of *Epëira apoclisa* of a medium size, will convey some idea of the elaborate operations performed by the *Epëiræ* in the construction of their snares. The mean distance between two adjacent radii, in a net of this species, is about seven-tenths of an inch; if, therefore, the number 7 be multiplied by 20, the mean number of viscid globules which occur on one-tenth of an inch of the elastic spiral line, at the ordinary degree of tension, the product will be 140, the mean number of globules deposited on seven-tenths of an inch of the elastic spiral line; this product multiplied by 24, the mean number of circumvolutions described by the elastic spiral line, gives 3360, the mean number of globules contained between two radii; which multiplied by 26, the mean number of radii, produces 87,360, the total number of viscid globules in a finished net of average dimensions. A large net, fourteen or sixteen inches in diameter, will be found, by a similar calculation, to contain upwards of 120,000 viscid globules, and yet *Epëira apoclisa* will complete its snare in about forty minutes if it meet with no interruption.

In the formation of their snares the *Epëiræ* appear to be regulated solely by the sense of touch, as various species when confined in spacious glass jars placed in situations absolutely impervious to

light construct nets which do not exhibit the slightest irregularity of plan or defect of structure *.

Dr. Lister supposed that spiders are able to retract the lines they spin within the abdomen, and whoever minutely observes the *Epëirœ*, when fabricating their snares, will almost be induced to entertain the same opinion. The viscid line produced by these spiders in their transit from one radius to another is sometimes drawn out to a much greater extent than is necessary to connect the two, yet, on approaching the point at which it is to be attached, it appears to re-enter the spinners, till it is reduced to the exact length required. This optical illusion, for such it is, is occasioned by the extreme elasticity of the line, which may be extended greatly by the application of a slight force, and on its removal will contract proportionally. By this property the viscid spiral line is accommodated to the frequent and rapid changes in distance which take place among the radii when agitated by winds or other disturbing forces, and by it insects, which fly against the snare, are more completely entangled than they otherwise could be without doing extensive injury to its frame-work †.

Complicated as the processes are by which these symmetrical nets are produced, nevertheless, young spiders, acting under the influence of instinctive impulse, display, even in their first attempt to fabricate them, as consummate skill as the most experienced individuals.

Although spiders are not provided with wings, and, consequently, are incapable of flying, in the strict sense of the word; yet, by the aid of their silken filaments, numerous species, belonging to various genera, are enabled to accomplish distant journeys through the atmosphere. These aërial excursions, which appear to result from an instinctive desire to migrate, are undertaken when the weather is bright and serene, particularly in the autumn, both by adult and immature individuals, and are effected in the following manner. After climbing to the summits of different objects, they raise themselves still higher by straightening the limbs; then elevating the abdomen, by bringing it from the usual horizontal position into one almost perpendicular, they emit from the spinners a small quantity of viscid fluid, which is drawn out into fine lines by the ascending current occasioned by the rarefaction of the air contiguous to the heated ground. Against these lines the current of rarefied air impinges, till the animals, feeling themselves acted upon with sufficient force, quit their hold of the objects on which they stand and mount aloft.

Spiders do not always ascend into the atmosphere by a vertical movement, but are observed to sail through it in various directions; and the fact admits of an easy explanation when the disturbing causes by which that subtile medium is liable to be affected are taken into consideration. A direction parallel to the horizon will be given by a current of air moving in that plane; a perpendicular one, by

* Zoological Journal, vol. v. p. 181–188. Transactions of the Linnæan Society, vol. xvi. p. 477–479. Researches in Zoology, p. 253–270.

† Researches in Zoology, pp. 267, 268.

the ascent of air highly rarefied; and directions intermediate between these two will, in general, depend upon the composition of forces. When the horizontal and vertical currents are equal in force, the line of direction will describe an angle of 45° nearly with the plane of the horizon; but when their forces are unequal, the angle formed with that plane will be greater or less as one current or the other predominates.

The manner in which the lines of spiders are carried out from the spinners by a current of air appears to be this. As a preparatory measure, the spinning mammulæ are brought into close contact, and viscid matter is emitted from the papillæ; they are then separated by a lateral motion, which extends the viscid matter into fine filaments connecting the papillæ; on these filaments the current impinges, drawing them out to a length which is regulated by the will of the animal; and on the mammulæ being again brought together the filaments coalesce and form a compound line.

Many intelligent naturalists entertain the opinion that spiders can forcibly propel or dart out lines from their spinners; but when placed on twigs set upright in glass vessels with perpendicular sides containing a quantity of water sufficient to immerse their bases completely, all the efforts they make to effect an escape uniformly prove unavailing in a still atmosphere. However, should the individuals thus insulated be exposed to a current of air either naturally or artificially produced, they immediately turn the abdomen in the direction of the breeze, and emit from the spinners a little of their viscid secretion, which being carried out in a line by the current becomes connected with some object in the vicinity, and affords them the means of regaining their liberty. If due precaution be used in conducting this experiment, it clearly demonstrates that spiders are utterly incapable of darting lines from their spinners, as they cannot possibly escape from their confinement on the twigs in situations where the air is undisturbed, but in the agitated atmosphere of an inhabited room they accomplish their object without difficulty. Similar means are frequently employed by spiders in their natural haunts for the purposes of changing their situation and fixing the foundations of their snares.

The webs named gossamer are composed of lines spun by spiders, which on being brought into contact by the mechanical action of gentle airs adhere together, till by continual additions they are accumulated into irregular white flakes and masses of considerable magnitude. Occasionally spiders may be found on gossamer-webs after an ascending current of rarefied air has separated them from the objects to which they were attached, and has raised them into the atmosphere; but as they never make use of them intentionally in the performance of their aëronautic expeditions, it must always be regarded as a fortuitous circumstance*.

* Transactions of the Linnæan Society, vol. xv. p. 449–459. Researches in Zoology, p. 229–252.